NEW MEXICO STATE UNIVERSITY

A Gravity Balanced Test Stand For Flight Testing of MAVs

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MAE DEPARTMENT
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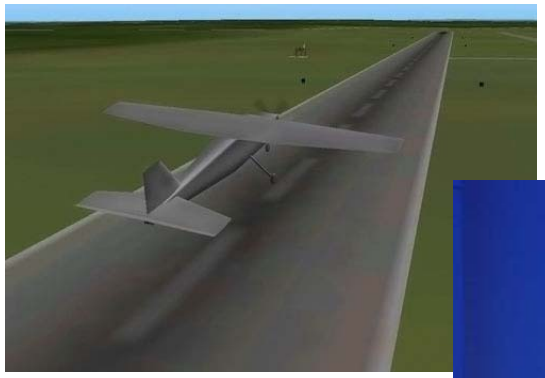
PSL
Physical Science Laboratory

Overview

- Purpose of the test stand
- Innovations in our test stand
- Gravity Balancing Theory
- Simulation of the test stand

Purpose of The Testing Stand

- No Crashing, Safety, Simple Operation, ……



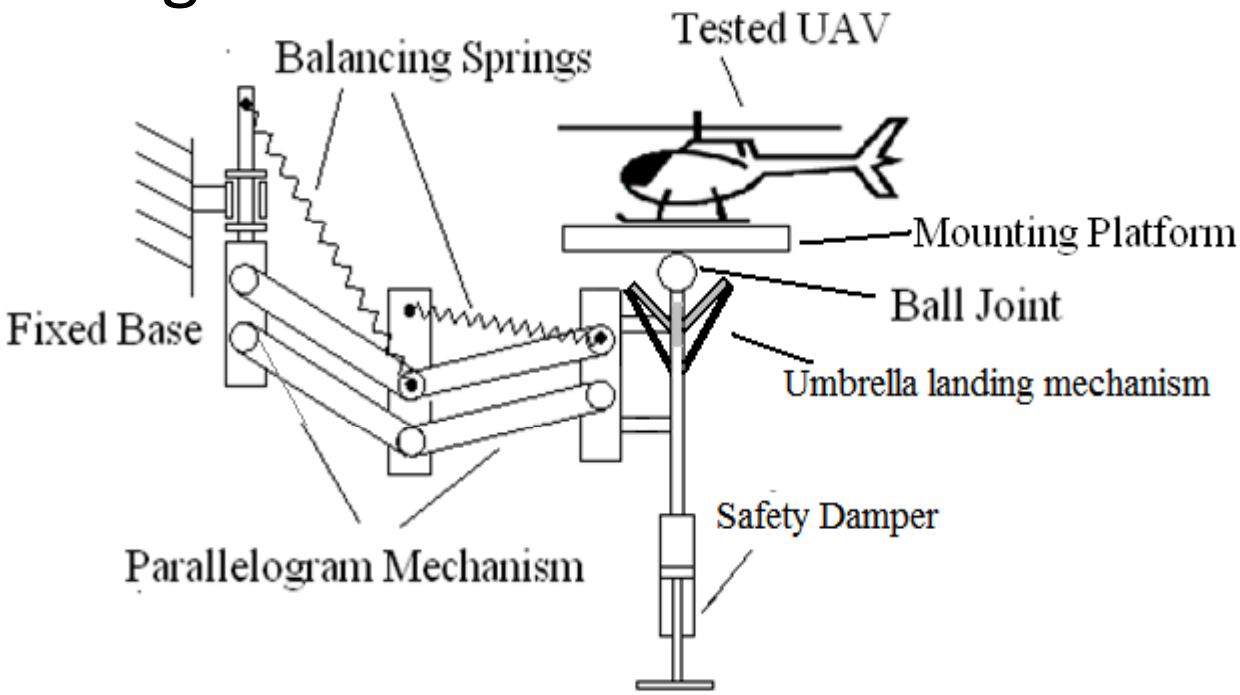
Simulation Testing

Testing with a Stand

Outdoor Testing

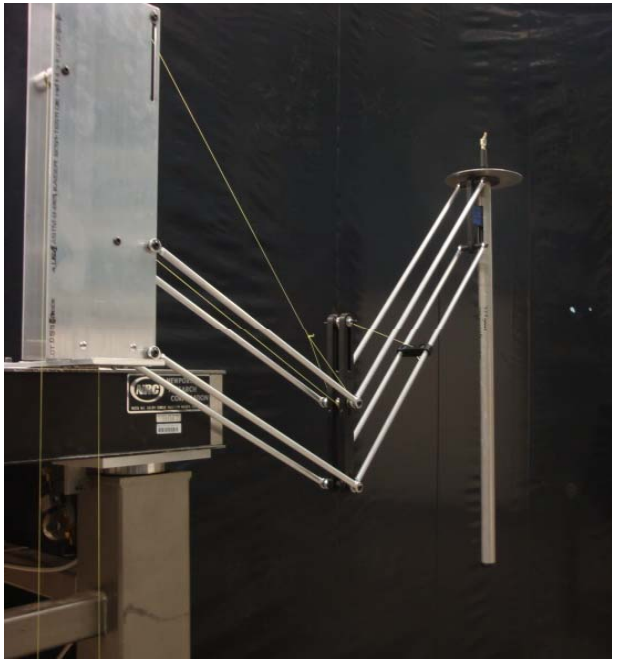
Innovations in Our Test Stand

- Higher Degree of freedom
- Up Righting Mechanism
- Gravity Balancing

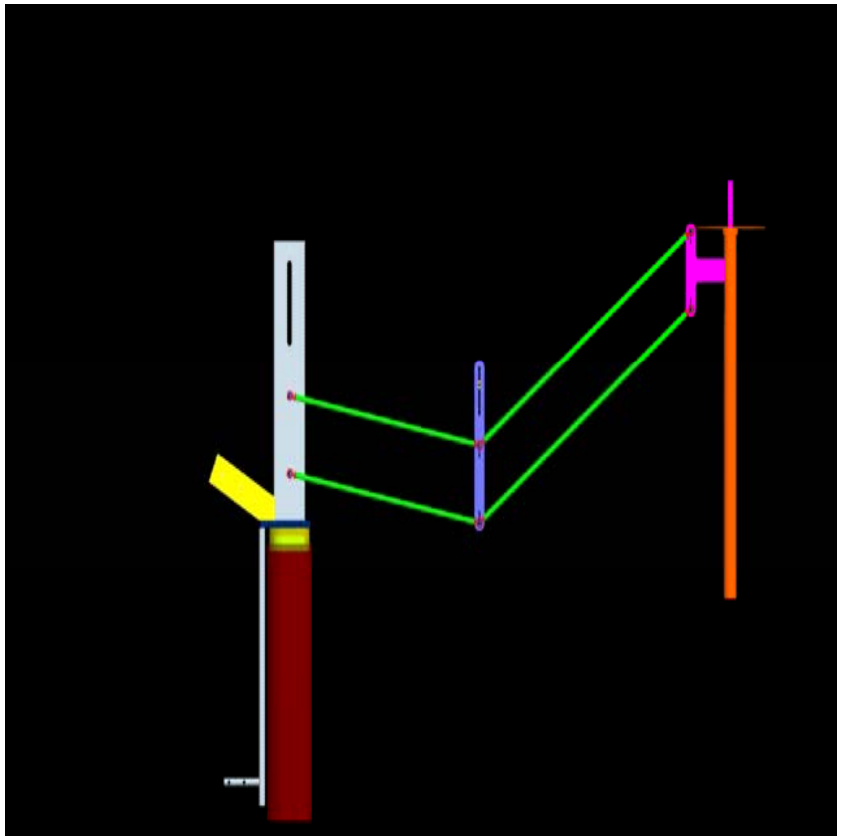


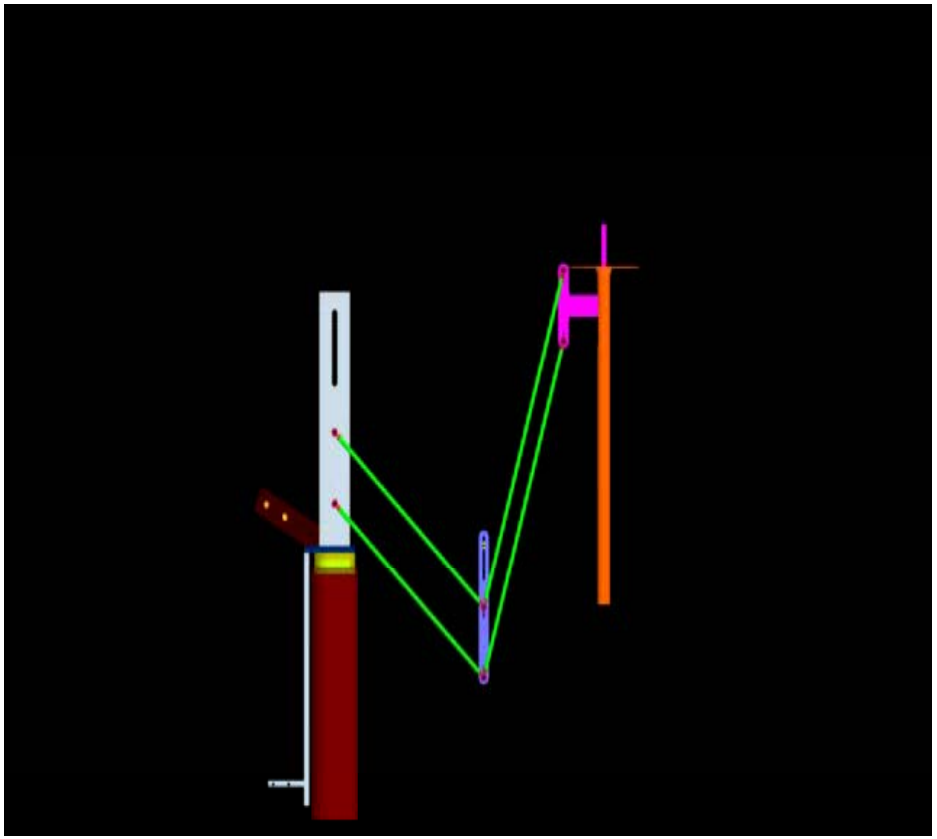
Innovations in Our Test Stand

- Higher degree of freedom



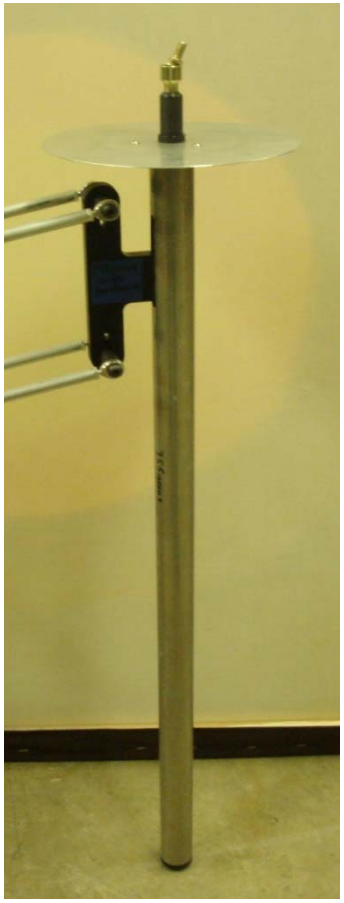
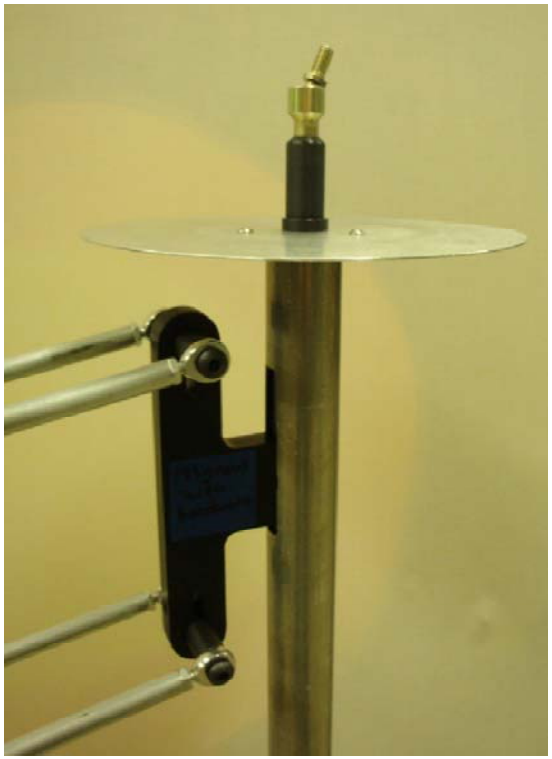
Innovations in Our Test Stand

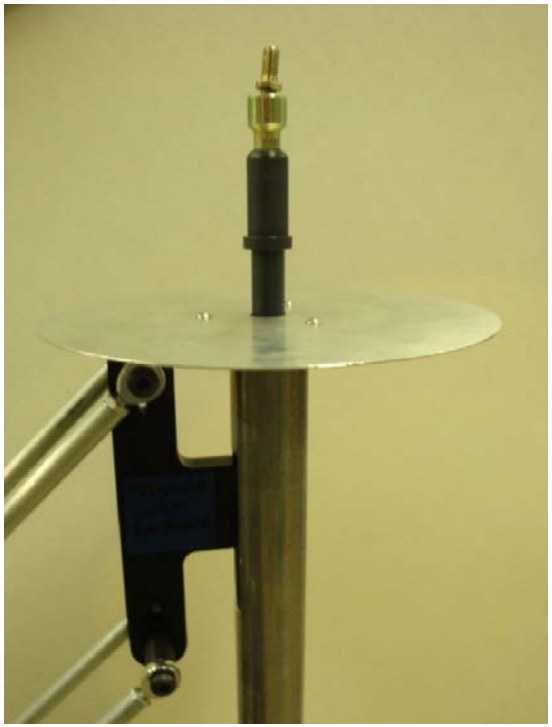




Innovations in Our Test Stand

- Up righting mechanism



Innovations in Our Test Stand

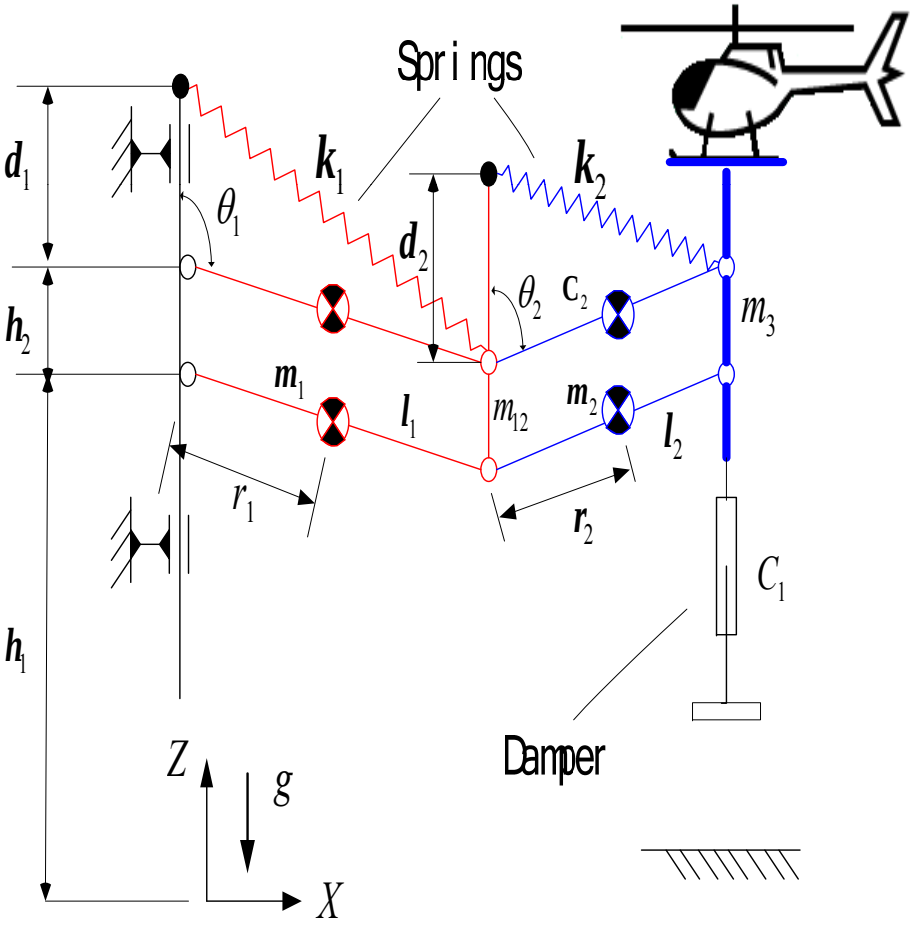
- Gravity Balancing

$$V_{p\lg m1} = 2(h_1 + r_1\cos\theta_1)m_1 g + h_2 m_1 g + (h_1 + l_1\cos\theta_1 + r_{12})m_{12} g$$

$$V_{p\lg m2} = 2(h_1 + l_1\cos\theta_1 + r_2\cos\theta_2)m_2 g + h_2 m_2 g + (h_1 + l_1\cos\theta_1 + l_2\cos\theta_2 + r_3)m_3 g$$

$$V_{s1} = \frac{1}{2}k_1(d_1^2 + l_1^2 - 2d_1 l_1\cos\theta_1)$$

$$V_{s2} = \frac{1}{2}k_2(d_2^2 + l_2^2 - 2d_2 l_2\cos\theta_2)$$

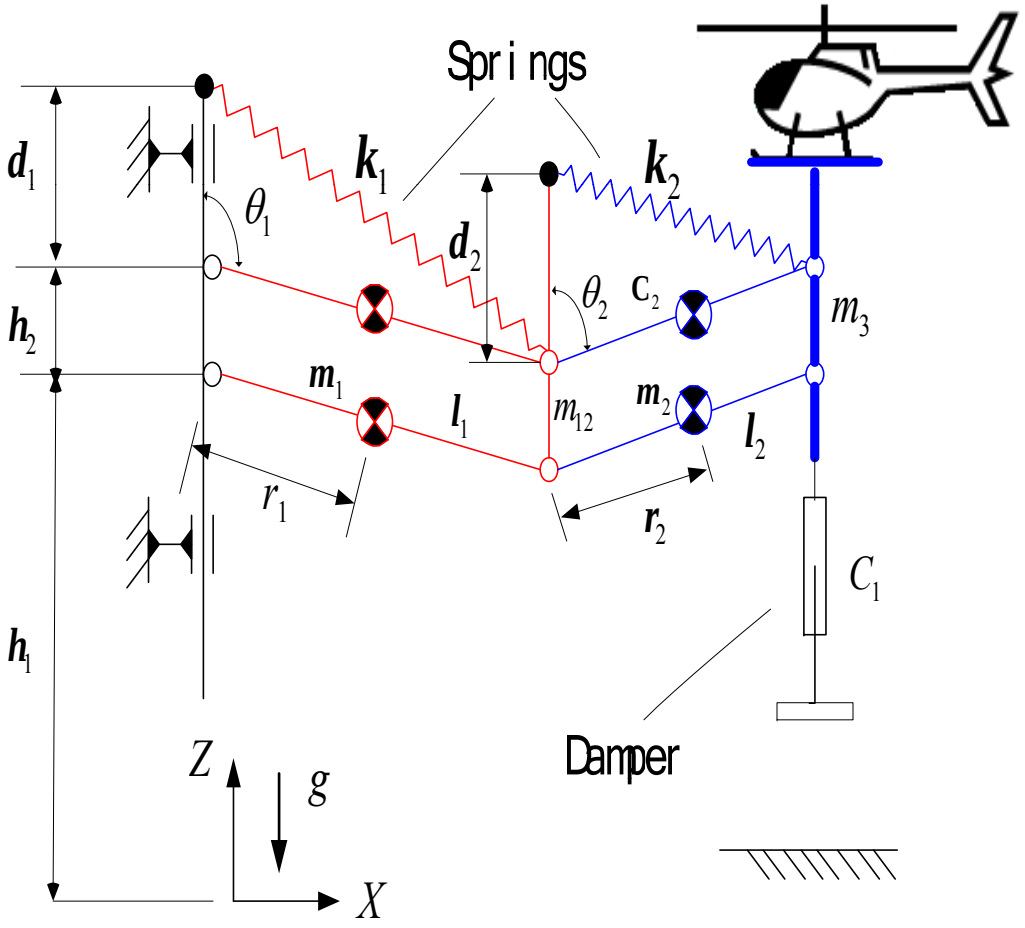


Gravity Balancing Theory

- Spring constants

$$k_1 = \frac{2m_1 r_1 + l_1(2m_2 + m_{12} + m_3)}{l_1 d_1} g$$

$$k_2 = \frac{2m_2 r_2 + l_2 m_3}{l_2 d_2} g$$

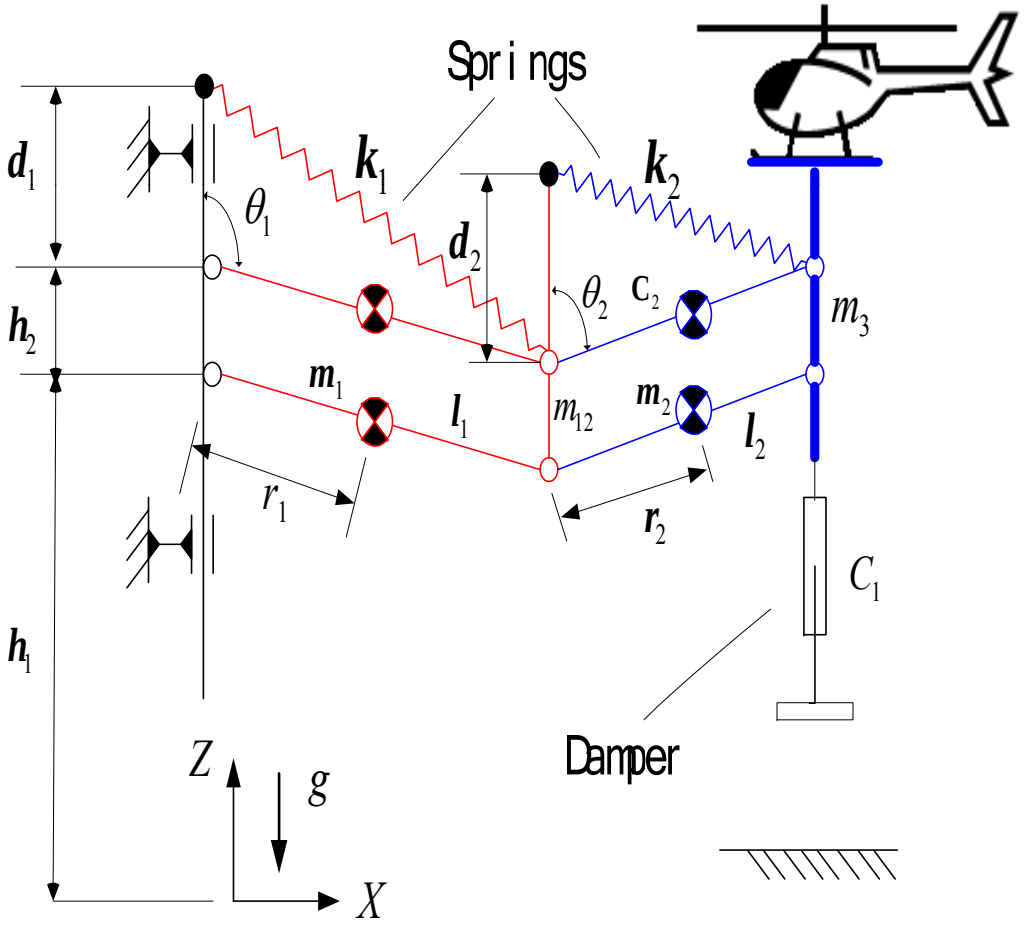


Gravity Balancing Theory

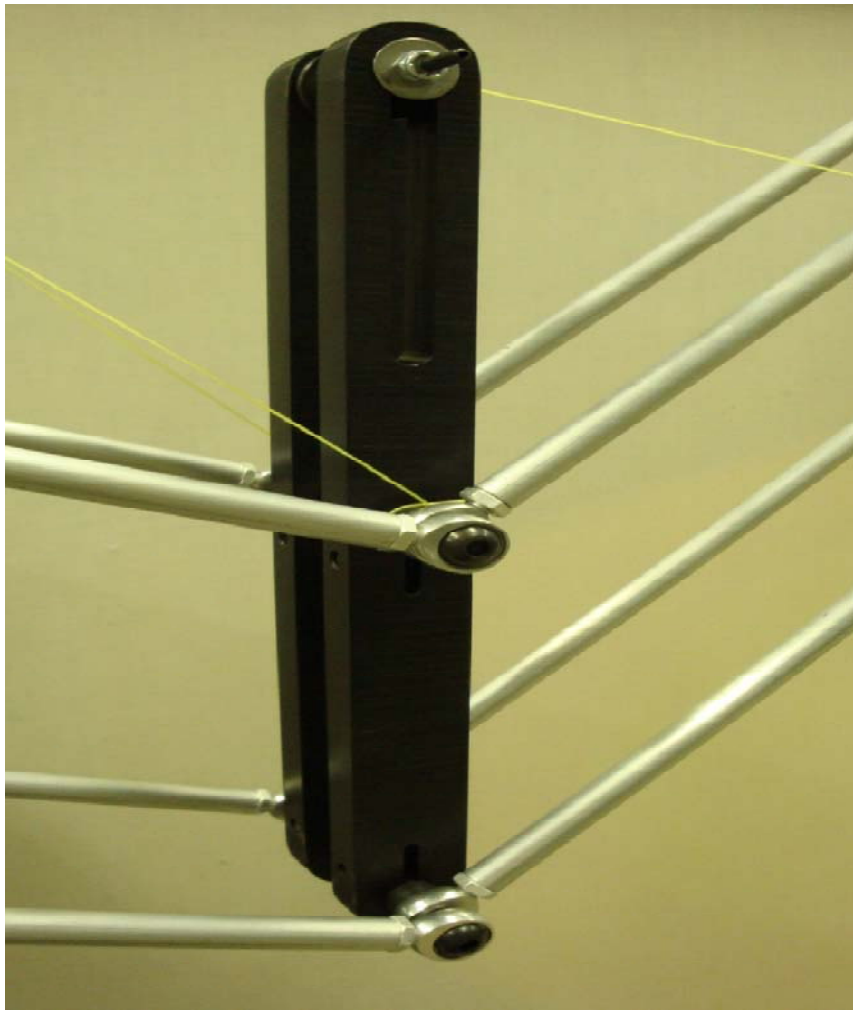
- Adjustability

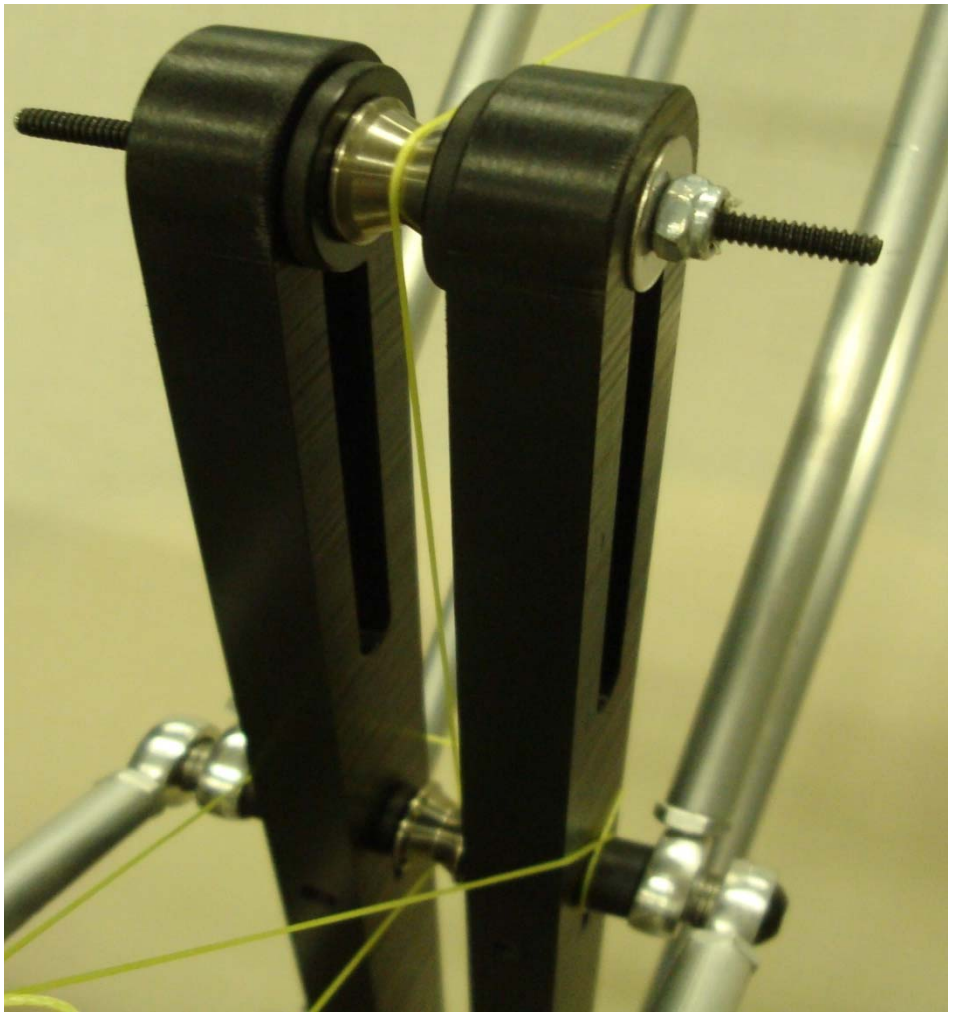
$$d_1 = \frac{2m_1 r_1 + l_1(2m_2 + m_{12} + m_3)}{l_1 k_1} g$$

$$d_2 = \frac{2m_2 r_2 + l_2 m_3}{l_2 k_2} g$$



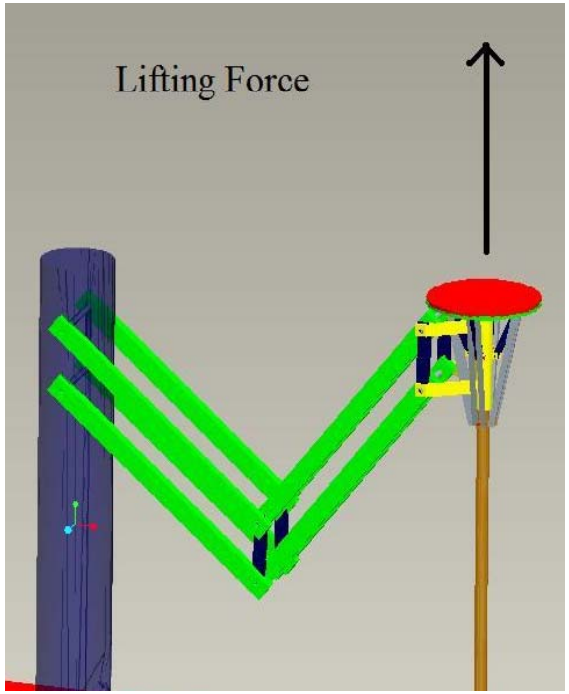
Gravity Balancing Theory

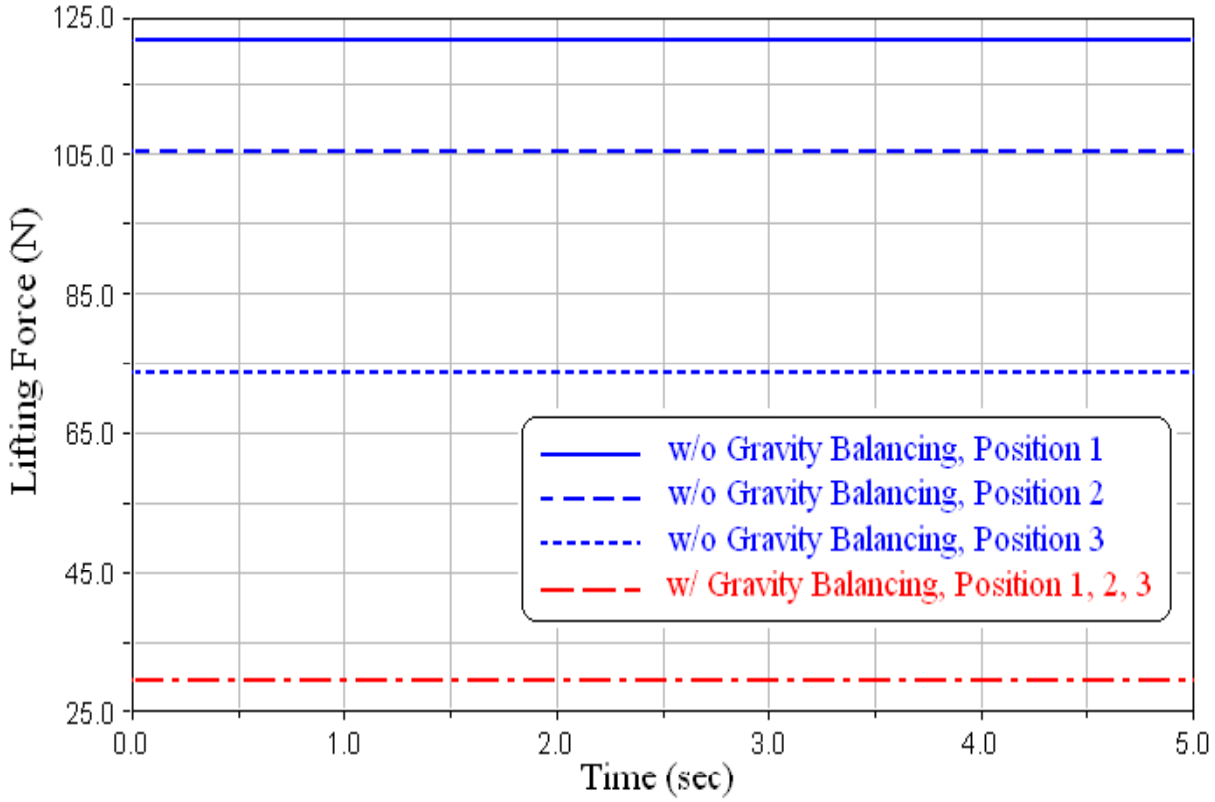




Simulation

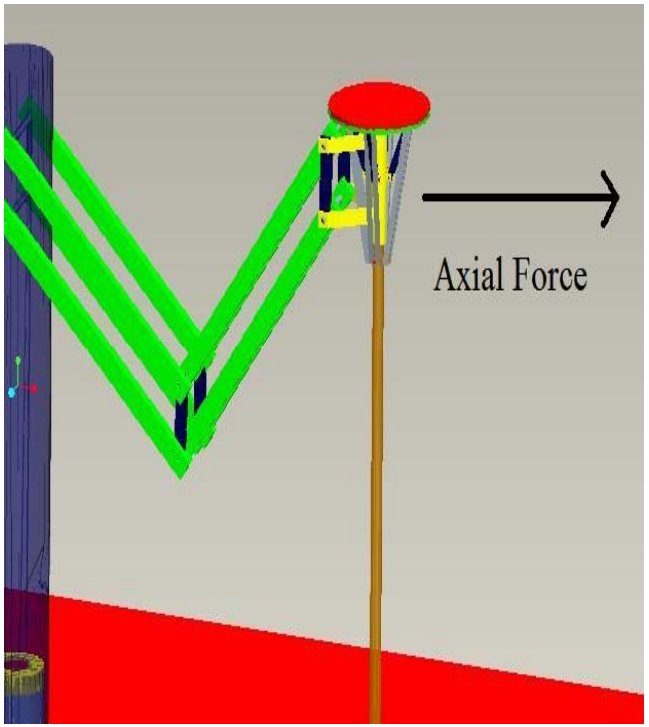
- Required lifting force

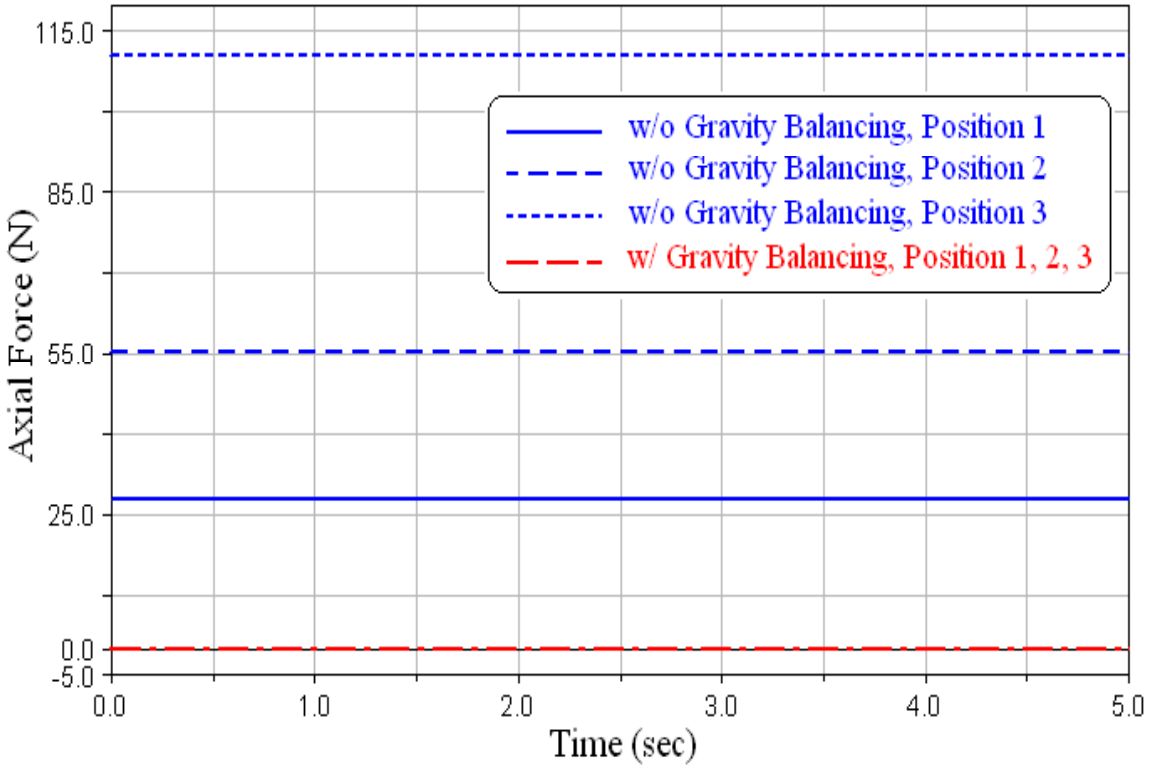




Simulation

- Axial force

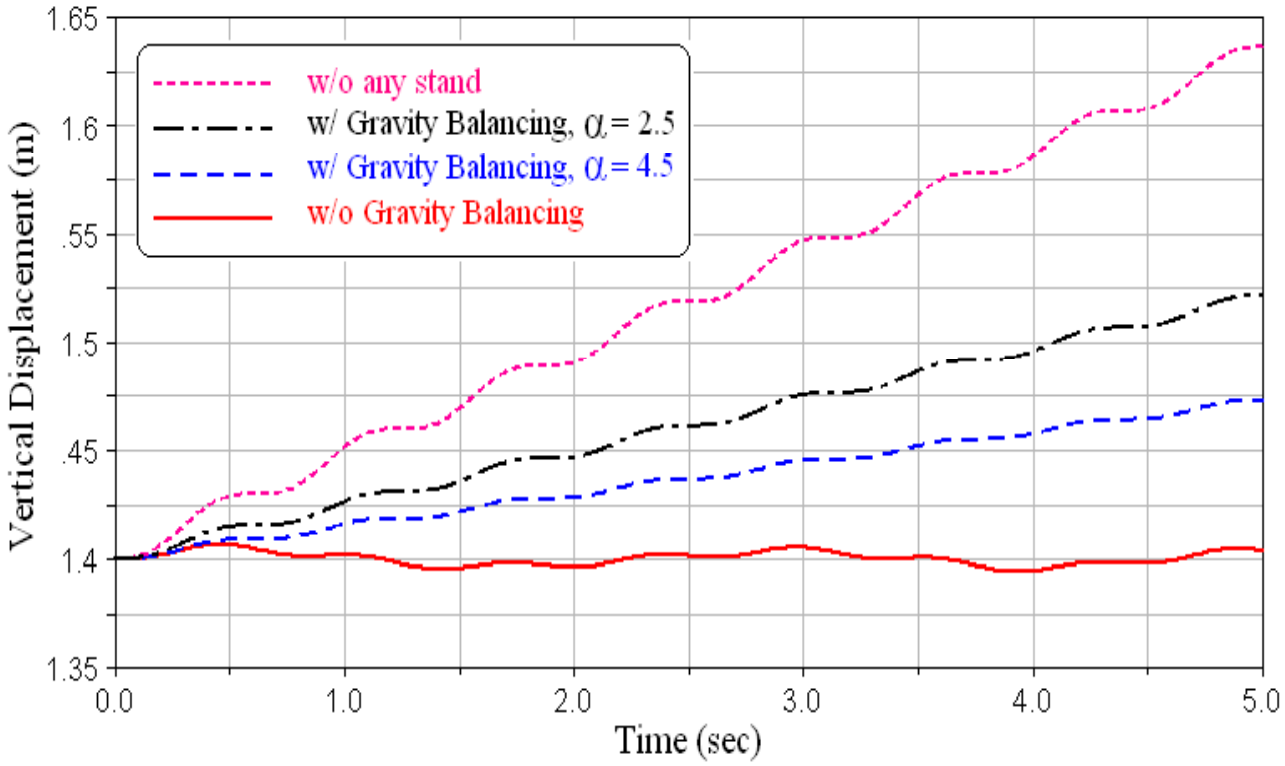




Simulation

- Vertical Displacement

$$\alpha = \frac{\text{mass of test stand}}{\text{mass of MAV}}$$



Conclusions and Further Work

- Gravity balancing is necessary for MAVs.
- Design has been done.
- Hardware prototyping is underway.
  - Complete the hardware prototype.
  - Verify the gravity balancing capability.
  - Investigate dynamic behavior.

Questions?

Many Thanks to

- Physical Science Lab / Air Force (Sponsor)
- NMSU Aerospace Program
- NASA Space Grant